10/565379
IAP15 Rec'd PCT/PTO 23 JAN 2006

P802094/WO/1

DaimlerChrysler AG

Device for actuating a torque transmission unit

The invention relates to a device for actuating a torque transmission unit according to the preamble of claim 1.

Controllable torque transmission units are used particularly in motor vehicles as a torque converter for starting, as a disconnecting element for a shift sequence, as an overload safeguard, as a torsional damper or as a brake. The torque transmission unit may be manually, electrically and/or hydraulically actuated. According to DIN a distinction is drawn between remotely actuated, engine speed-actuated, torque-actuated and/or directionally actuated torque transmission systems. Furthermore, the torque can basically be transmitted non-positively and/or positively. A non-positive transmission can in turn be divided into a frictional, hydrodynamic, hydrostatic, electrodynamic, electrostatic or magnetic transmission, the methods of transmission being combinable with one another.

DE 196 52 244 A1 discloses a generic device having an actuator and a control unit for actuating a torque transmission unit. The actuator has a drive motor, which acts on a master cylinder by way of a drive mechanism and a follower, it being possible to register the movement of the follower by way of a travel sensor. The master cylinder is connected by a hydraulic line to a slave cylinder. The slave cylinder is operatively connected to a release bearing, which serves to actuate the friction clutch.

In order to compensate for wear, tolerances and other deviations or changes, a so-called point of engagement adjustment is performed, the point of engagement being defined by a time at which torque transmission commences during the closing sequence. The point of engagement adjustment is described as a process in which a software-stored or used clutch characteristic curve is adjusted or brought more into line with the clutch characteristic curve actually prevailing.

In this process, with the internal combustion engine idling, and in particular with a gear engaged and the brake applied, or in an operating condition in which a slight variation of the transmissible clutch torque does not lead to any change in the drive condition (cf. in particular DE 196 52 244 A1, column 18, line 33 ff), the clutch is slowly closed. From the finding that an increase in the clutch torque produces a broadly equal increase in the engine torque (cf. in particular DE 196 52 244 A1 column 17, line 34 ff), an existing clutch torque can be inferred from a registered engine torque. If, at a clutch travel assigned to the stored point of engagement, the engine torque increases by an amount of 9 Nm, for example, that is assigned to a clutch torque at the point of engagement, the point of engagement is correctly set or correctly stored. If this is not the case, the point of engagement is adjusted for the next closing sequence of the clutch.

The particular object of the invention is to provide a device by means of which a faster closing sequence of a torque transmission unit from an open position to a closed position can be achieved, at least without significant penalties in terms of comfort. According to the invention this object is achieved by the features

of claim 1. Further developments are set forth in the dependent claims.

The invention relates to a device for actuating a torque transmission unit, in particular a frictional engagement unit in an at least partially automated transmission of a motor vehicle, comprising an actuator and a unit which are used to control the power flow via the torque transmission unit.

According to the invention the unit activates the actuator during a closing sequence of the torque transmission unit causing it to pass from an open position at least to a point of engagement of the torque transmission unit in a first mode which is characterized by increased speed and/or increased pressure, and the unit switches the actuator into a subsequent mode at a time varying as a function of at least one characteristic variable sensed during the closing sequence. Transient and persistent interference variables and fluctuations produced in operation, particularly those due to varying temperature values in the torque transmission unit and to variations in the point of engagement caused by wear within the torque transmission unit, can easily and reliably be compensated for and the actuator can be activated in the first mode characterized by increased speed and/or increased pressure. The closing sequence can be readily and constructively speeded up and any penalties in terms of comfort can be at least largely avoided. Costly temperature models can be avoided. Moreover, it is readily possible to draw conclusions with regard to the state of the torque transmission unit. The state of the torque transmission unit at the time of the shift sequence can be taken into account without having to resort to data that have been determined in previous shift sequences or test running.

The term open position is here taken to mean a position in which basically no power or no torque is being transmitted via the torque transmission unit. The term point of engagement is taken to mean a time at which substantive torque transmission commences, and in particular a time at which friction surfaces of the torque transmission unit in the form of a frictional engagement unit are brought into contact for the first time. The term closed position is taken to mean a position in which basically no slip occurs within the torque transmission unit.

The solution according to the invention is basically suitable for the actuation of many types of torque transmission unit. For example, where the torque transmission unit is designed as a brake, a rapid, precise and reproducible reaction to control signals from the driver of a motor vehicle can advantageously be achieved. In a further development of the invention the unit can be used to shift the automated transmission from a neutral position into a drive position by means of the torque transmission unit or to perform a process for switching on an automatic transmission. In such shift sequences the actuator can be activated for an exceptionally long period in a first mode, affording exceptional potential for time savings.

If the actuator is of hydraulic design, it can very advantageously be integrated into an automated transmission system. In principle, however, other actuators that might suggest themselves to the person skilled in the art are also feasible, such as electrical or electromagnetic actuators, for example.

During a charging phase, hydraulic actuators can be operated in the first mode here characterized in particular by high pressure and a high closing speed. Through an enlargement of a pressure chamber and by means of a piston, friction surfaces of the torque transmission unit can be rapidly brought together, brought into contact at a point of engagement and then pressed together. The charging phase and a part of a power-up phase, following the charging phase and characterized by a sub-critical power or torque transmission, can together form a high-pressure phase. Through observation of the characteristic variable and through prompt cutting off of the first mode it is possible to ensure that unwanted acceleration values do not occur at any time.

If the characteristic variable sensed is defined at least substantially by a variable varying as a function of a speed differential within the torque transmission unit, this variable can be determined with particular ease and precision. Furthermore, the characteristic variable varies directly with a torque transmission varying over the torque transmission unit.

If the unit switches the actuator into the subsequent mode as soon as a characteristic variable, defined at least substantially by the value of the speed differential, is less than a predefined proportion of a maximum sensed value, which this characteristic variable has assumed in the period that has elapsed since the beginning of the closing sequence, it is possible, through selection of the value as characteristic variable, to treat both positive and negative speed differentials uniformly. Furthermore, by particular reference to a maximum, a rapid, comfortable and at least largely reproducible closing sequence can be achieved, despite fluctuations of the speed

differential and especially also in the case of opening and closing sequences in rapid succession.

In one development of the invention the characteristic variable is at least largely proportional to the value of the speed differential, and the proportion of the maximum value at which switching to the subsequent mode occurs is between 70% and 95%. This firstly serves to ensure that operation in the first mode can be terminated after the longest possible time, without incurring penalties in terms of comfort, and secondly it advantageously avoids the possibility of random fluctuations in the speed differential leading to premature switching to the subsequent mode.

In a further development of the invention the subsequent mode is a holding mode, when the sensed value of the characteristic variable is less than a predetermined value. If small speed differentials occur, it is possible without penalties in terms of comfort to switch directly from the first mode into a holding mode, which is characterized by full torque transmission and insignificant speed differential, and the shift sequence can in these cases be advantageously shortened.

In a further development of the invention the torque transmission unit is a plate clutch in an automatic transmission, which is particularly advantageous in affording large friction surfaces.

According to the invention, moreover, the unit controls the actuator in the first mode and regulates it in the subsequent mode. This means that in the first mode it is advantageously possible to resort to simple and robust electronics, and in the subsequent mode an adaptive control can be achieved over the transient

torque transmission behavior via the torque transmission unit.

Further advantages are set forth in the following description of the drawing. The drawing represents one exemplary embodiment of the invention. The description and the claims contain numerous features in combination. The person skilled in the art will also give suitable consideration to the features in isolation and will be capable of combining these in other suitable combinations.

In the drawing:

Fig. 1 shows a schematic drawing of a device for actuating a torque transmission unit,

Fig. 2 shows a time curve of an input speed and an output speed of an automatic transmission and an engine speed during a closing sequence of the torque transmission unit,

Fig. 3 shows a time curve of the input speed in the case of a rapid R-N-D shift sequence and

Fig. 4 shows a time curve of the input speed in the case of a rapid D-N-D shift sequence whilst driving.

Fig. 1 shows a schematic representation of a device according to the invention for actuating a torque transmission unit 10 in a motor vehicle automatic transmission (not shown) having a converter for transmitting torques between an input shaft 31 and an output shaft 24 in an output position. The device comprises an actuator 12 and a control unit 13 for actuating the torque transmission unit 10. By way of the control unit 13 the automatic transmission can be brought into a neutral position N and into a drive position D or R by means of the torque transmission

unit 10 in the form of a wet-plate clutch. In particular, the control unit 13 can serve, via the torque transmission unit 10, for controlling and regulating an activation sequence for establishing a non-positive connection between an engine and the drive wheels of a motor vehicle.

A sensor 18 capable of sensing a time curve of an input speed 14 used as a characteristic variable is arranged on the input shaft 31. The input speed 14 on the sensor 18 can be read off by the control unit 13 for controlling the actuator 12 comprising a valve slide and an operating magnet. An output speed 26 is calculated from the speed of the vehicle by means of a known transmission ratio and is basically constant during the shift sequence lasting only fractions of a second.

A pump 19 is connected to a pressure chamber 21 of the torque transmission unit 10 by way of a first part of a pressure duct 20, via the valve slide of the actuator 12 and via a second part of the pressure duct 20 and can be hydraulically coupled to the pressure chamber 21 and uncoupled therefrom by the actuator 12. The second part of the pressure duct 20 is formed from a connecting line 32 extending from the valve slide to a bushing 27, a radial bore 39 in the bushing 27, a peripheral groove 28 in the output shaft 24 and by a first radial bore 40, an axial bore 38 and second radial bore 29 in the output shaft 24.

Fig. 2 in a schematic representation shows the input speed 14, the output speed 26 and an engine speed 36 during a closing sequence as a function of the time, and specifically in a shift sequence from a neutral position N to a drive position D when the motor vehicle is stationary. In response to a corresponding shift

signal, the control unit 13 activates the actuator 12 for the shift sequence of the torque transmission unit 10 from an open position in a first mode characterized by increased speed and increased pressure. In this case the valve slide is run fully open and the pressure chamber 21 is subjected to a high to maximum pressure. The output speed 26 of the output shaft 24 is initially less than the input speed 14, which owing to losses on the converter is less than the engine speed 36. The input speed 14 fluctuates due to fluctuations of the engine speed 36. The pressure chamber 21 is expanded by the moving piston 22, and plates 23 of the torque transmission unit 10 in the form of a plate clutch are brought together.

A maximum value 17, which the input speed 14 has assumed since a beginning 33 of the closing sequence, is stored in the control unit 13. For this purpose a start value is increased with the current value of the input speed 14 until a maximum is attained at a time 34. This is determined by a comparison of the current speed value and speed value stored immediately prior to this.

At a point of engagement 11 or at a so called kiss point a charging phase 30 ends and the plates 23 touch one another for the first time and are pressed more strongly against one another as the shift sequence progresses. This gives rise to an incipient torque transmission at the point of engagement 11 which increases as the shift sequence progresses, the torque transmission leading to a matching of the input speed 14 and the output speed 26. At a termination point 16 the value of a speed differential 15 between the input speed 14 and the output speed 26 represents 80% of the maximum value 17 for the speed differential 15, which is greater than a predetermined threshold 25. The

control unit 13 then partially closes the valve slide of the actuator 12 and at this termination point 16 defined by the sensed input speed 14 the actuator 12 switches over to a subsequent mode characterized by regulation of the torque transmission.

An alternative curve of an input speed 14′ during which the maximum value 17′ of the speed differential 15′ does not exceed the threshold 25 is represented as a dotted line. The device is then operated in the first mode until the input speed 14′ matches the output speed 26 and the control unit 13 switches the actuator 12 into a holding mode characterized by full torque transmission.

Fig. 3 shows a schematic representation of the time curve of the input speed 14, as observed in stationary or slowly moving motor vehicles with an automatic transmission, during an R-N shift sequence, rapidly followed by an N-D shift sequence or the reverse, or during a D-N-D or an R-N-R shift sequence. In a drive position the input speed 14 is equal to the output speed 26. In a shift from a drive position R or D into the neutral position N, the control unit 13 at an opening point 35 receives a shift signal and opens a valve (not shown) in the pressure chamber 21. With pressure in the pressure chamber 21 subsiding, the torque transmission unit 10 is brought into an open position by a spring mechanism (not shown). The engine, through a hydrodynamic coupling via the converter, speeds up input shaft 31 and the input speed 14 comes into line with the engine speed 36.

When shifting from the neutral position N to the drive position R or D, the control unit 13 at the beginning of the closing sequence receives a shift signal and the control unit 13 activates the actuator 12 in the first

mode. During the charging phase 30 no torque is transmitted via the torque transmission unit 10. The torque transmission commences after the point of engagement 11, but initially up to a time 37 is less than the torque acting on the input shaft 31 via the converter. Around this time 37 the speed differential 15 between the input speed 14 and the output speed 26 assumes its maximum value 17 and the input speed 14 subsequently comes into line with the output speed 26. If the speed differential 15 at a termination point 16 is less than a value of 80% of the maximum value 17, which is greater than the threshold value 25, the control unit 13 switches the actuator 12 to the subsequent mode.

Fig. 4 shows the time curve of the input speed 14 after a disengagement sequence, which is rapidly followed by an engagement sequence in a swiftly moving motor vehicle. After opening of the torque transmission unit 10 at the opening point 35, the input speed 14 falls below the threshold 25. In the event of a return to the previous drive position, the control unit 13 at the start 33 of the shift sequence receives a shift signal and the control unit 13 activates the actuator 12 in the first mode. During the charging phase 30 no torque is transmitted via the torque transmission unit 10. The torque transmission commences after the point of engagement 11, but initially up to a time 37 is less than the torque acting on the input shaft 31 via the converter, which brakes the input shaft 31. Around this time 37 the speed differential 15 between the input speed 14 and the output speed 26 assumes its maximum value 17 and the input speed 14 subsequently comes into line with the output speed 26. If the value of the speed differential 15 at a termination point 16 is less than a value of 80% of the maximum value 17, which is

greater than the threshold value 25, the control unit 13 switches the actuator 12 to the subsequent mode.